EVALUATION OF POTENTIAL SOIL CONTAMINATION FROM OPEN DETONATION DURING ORDNANCE AND EXPLOSIVES REMOVAL ACTIONS, FORMER FORT ORD, CALIFORNIA

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CATEGORY: UXO CLEARANCE

Introduction

From 1917 to 1994, the U.S. Department of the Army (Army) used Fort Ord, California (Plate 1), as a training and staging area for infantry troops. Ordnance and explosives (OE) were used at various sites in two main areas known as the Multi-Range Area (MRA) and the Inland Training Ranges. Today, both of these areas contain sites where unexploded UXO items are known or are suspected to exist. The location and removal of these OE is necessary before the land can be safely transferred for public use.

To date, approximately 90 known or suspected OE sites and subsites have been identified at the former Fort Ord (Plate 2). Ongoing investigations and site evaluations are being performed to assess the presence of UXO at each known or suspected site. Because of the size of the MRA and the dispersed nature of the sites that comprise the Inland Training Ranges, the Army intends to remove and destroy UXO by performing open detonations (as appropriate) at various temporary explosive ordnance detonation (EOD) locations within OE sites. These areas will be used only to the extent necessary to complete UXO sampling and removal actions at the individual sites in the immediate vicinity. UXO items found and deemed unsafe to move will be blown in place.

In November 1998, the Army decided to investigate OE at the former Fort Ord in an Ordnance and Explosives Remedial Investigation/Feasibility Study (OE RI/FS). As part of the OE RI/FS, UXO sampling, removal, and disposal measures will be evaluated for all OE sites at the former Fort Ord. Because the process of open detonation could potentially contaminate surface and near-surface soil, an evaluation of potential soil contamination resulting from UXO detonations will be performed as part of the overall RI/FS investigation at Fort Ord.

This paper outlines the goals and procedures for the collection and analysis of soil samples from selected temporary EOD areas at Fort Ord. The primary goal of the study is to determine a conservative (protective of human health), upper-bound limit on the amount of OE that can be demolished at a single location without approaching levels of concern for potential contaminants in soil. A previous study performed by Nichols Research Corporation (NRC, 1996) indicated that detonations in a single area involving up to 500kg (1100 lbs.) net explosive weight (NEW) are not likely to produce contaminant levels of concern in soil. However, those conclusions may not be directly applicable to the former Fort Ord because of differences in soil type and OE items known or expected to be encountered. This site-specific study, therefore, relies on knowledge gained from previous studies but is tailored to the specific OE profile expected at the former Fort Ord. The results of this investigation may confirm that current plans for EOD operations may proceed without modification. Alternatively, results may indicate that EOD operations should be modified to ensure that explosive residues and byproducts do not exceed levels of concern in soil.

Source, Nature, and Extent of OE

Generally, any type of ordnance and explosives used by the infantry or in support of the infantry has been or could be found on the former Fort Ord (Table 1). OE found within the installation consists of conventional and practice munitions such as large-caliber projectiles, bombs, grenades, landmines, mortars, rockets, detonators, blasting caps, fuses, and small arms (7.62 mm, 5.56 mm, 50 caliber, 30 caliber). Pyrotechnic OE items include flares, signals, simulators, and smoke-screen charges. Explosives, including TNT demolition charges, have also been found within the installation.

Regulatory Issues

In 1990, the former Fort Ord was placed on the National Priorities List, which requires responses to releases of hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Although UXO was not included in the Federal Facility Agreement (FFA) the Army decided to conduct the cleanup of UXO as a removal action under CERCLA, separate from the FFA. Accordingly, the Army proceeded with the UXO cleanup process pursuant to the regulations of the National Contingency Plan (NCP), which prescribes the process of removal actions under CERCLA. As stated above, the Army has decided to evaluate UXO at the former Fort Ord in an OE RI/FS. The removal and destruction of UXO and an evaluation of potential impacts of this process have been included as part of the Fort Ord RI/FS program.

Potential Contaminants of Concern

The list of target analytes from the NRC study (Table 2) was considered as an initial list of potential contaminants of concern for UXO removal activities at the former Fort Ord. The results of the NRC study, indicate that even with much larger net explosive weight detonations at a single location than are anticipated for ordnance and explosives removal activities at the Former Fort Ord, none of the semivolatile compounds listed in Table 1 were detected in soil samples.

Tests conducted by the Army and other federal agencies between 1989 and 1990 at Sandia National Laboratories in Albuquerque, New Mexico (*Army, 1992*), found that detonations of various OE-related energetic materials within a large chamber (the Bang Box) did not result in detectable concentrations of semivolatile compounds.

On the basis of the NRC and Bang Box findings, semivolatile compounds are not included as potential contaminants of concern for ordnance and explosives removal activities at the former Fort Ord. Therefore, the potential contaminants of concern that will be evaluated in this investigation are nitroaromatic/nitramine compounds and metals.

SAMPLING PROCESS DESIGN

The overall objective of this investigation is to evaluate whether EOD operations at the former Fort Ord need to be modified so that concentrations of OE-related products/residues (target analytes) in soil do not exceed screening levels protective of human health. An EOD operation is defined as either a single detonation or multiple detonations in close proximity (e.g., within 20 feet of each other) within a short time period (e.g., same day). The quantity of UXO material (NEW) that is consolidated for detonation at any one temporary EOD area will be limited by the quantity of UXO found at the specific OE site. Currently, no single detonation is expected to exceed 6.8 kg. (15 lbs.) net explosive weight, including the detonating charge, and no more than one or two detonations will occur at a single location.

Composite soil samples will be collected before (baseline) and after (post-EOD) EOD operations using the sampling process and methods described below. The EOD operations to be investigated represent typical scenarios for a given type of explosive device (e.g., pyrotechnics, mortars, grenades).

Factors considered in the optimization of the sampling design include the following:

- Products/residues in soil will occur as particulate nonvolatile compounds
- The highest concentrations of products/residues in soil will be nearest to the post-EOD crater
- The product/residue particulate deposition in soil will be fan-shaped. The dimension of the fan will depend on initial force of the blast and the wind velocity and direction
- The product/residue particulate deposition in soil is expected to decrease in a logarithmic pattern with downwind distance from the post-EOD crater
- Visual observation of the particulate deposition to determine the size and shape of the fan will optimize the sampling investigation design.
- Observations of previous EOD activities suggest the lengths of the visible particulate deposition fan will vary within the range of 200 to 500 feet downwind of the post-EOD crater.

Baseline Sampling

- To evaluate ambient concentrations of the chemicals of concern, baseline soil samples will be collected within 24 hours prior to an EOD operation (if possible, on the same day and just prior to the EOD event). The sample will be collected in the same manner as the post-EOD samples. Prevailing wind velocity and direction will be used to direct where the baseline samples are collected, so that the baseline samples are collected as close as possible to the post-EOD sampling locations.
- Baseline samples will include:
    - ◊ One four-point composite soil sample from within the predicted EOD crater
    - ◊ Nine three-point composite soil samples in the area of the predicted fan
    - ◊ One three-point composite duplicate soil sample

Single Detonation Event Sampling

Plate 3 shows a conceptual model of a single-detonation EOD operation. The area of particulate deposition is divided into three areas:

- Post-EOD crater (estimated diameter of 6 feet)

- The layer of soil in the immediate vicinity (i.e., estimated diameter of 30 feet) of the post-EOD crater that receives blast-induced particulate deposition that is unaffected by prevailing winds

- The layer of soil that receives visible windblown particulate deposition (i.e., fan; for an estimated lateral downwind distance of 200 to 500 feet).

A four-point composite soil sample will be collected to characterize the concentration of target analytes in the post-EOD crater. Typically, the diameter of the post-EOD crater does not exceed 6 feet. A total of nine three-point composite samples will be collected (one at each radial, as shown on Plate 3) to characterize the layer of soil in the immediate vicinity and in the fan. One QC duplicate three-point composite sample will be collected at the same location as one of the nine field composite samples. The sample collected at each downwind distance shall be a composite of three discrete subsamples; one subsample on the fan centerline and one subsample on each side of the centerline.

The distance from the centerline to the side samples (i.e., the radius of the blast-induced particulate deposition area) shall be approximately 15 feet.

Multiple Detonation Event Sampling

More than one detonation may occur in the same area in a single day, depending on the amount of available material to be detonated. Such multiple detonations will be assessed as a single EOD operation. Plate 4 shows an example of a multiple-detonation EOD operation where three separate detonations occur in the same area. (EOD operations consisting of three detonations are rare; most multiple EOD operations will consist of two detonations.) The sampling strategy is to combine the areal extents of the three fans to form a single composite fan, then sample within the composite fan as if it were a single fan. The imaginary centerline is formed from the approximate center of the three combined EOD craters to the edge of the composite fan in a downwind direction. The wind direction is assumed to be in the same general direction for each detonation. If the wind changes direction between detonations such that there is no fan overlap, the non-overlapping fans will be treated as separate detonations. Soil samples will be collected and composited in a similar manner as a single-detonation EOD operation. Instead of collecting four discrete samples within one post-EOD crater, as is the case for the single detonation, two discrete samples will be collected from each post-EOD crater and composited as one for multiple-detonation EOD operations.

Soil Sampling Program

Sample locations will be selected along the fan s downwind centerline at logarithmically increasing distances from the post-EOD crater such that nine sample distances are identified over the total downwind distance. Experience from previous EOD operations indicates the total downwind distances typically range from 200 to 500 feet.

Field personnel will measure and record data as follows:

- The compass heading (relative to true north) of the centerline from the center of the post-EOD crater

- The length of the fan centerline

- The diameter of the post-EOD crater

- Distance from the center of the post-EOD crater to each sample collected on the fan centerline (i.e., the radial distance from the center)

- Distance from the sample collected on the centerline to the other discrete samples that make up the composite sample (this distance should be approximately the same distance as the radius of the blast-induced area of particulate deposition; approximately 15 feet).

The OE contractor will survey the approximate center of the post-EOD crater using Global Positioning System (GPS) equipment. The purpose of surveying the center of the post-EOD crater and performing the bulleted items above is to be able to reproduce the post-EOD sample locations in the field should subsequent sampling or other activities be required.

Each composite sample shall consist of three discrete subsamples (four discrete subsamples in the post-EOD crater) of the upper 1 inch of soil. Each discrete subsample will be placed in a 16 ounce wide-mouth glass sample container with a Teflon-lined lid. Discrete samples will be composited onsite by combining the three (or four) discrete samples in one container and thoroughly mixed. As each discrete subsample is being collected, it will be moistened slightly with a mist sprayer using deionized (DI) water. This method (Jenkins et. al., 1997) was found by to minimize the potential for escape of target analytes present as fine particulates. A disposable scoop or reusable trowel will be used to collect the soil samples.

Summary

The Fort Ord OE RI/FS program will include an evaluation of the destruction of UXO and its potential impacts to soil quality as they pertain to human health concerns. Cleanup of ordnance and explosives at former Fort Ord will be accomplished by consolidating UXO in temporary EOD areas that will be utilized for no more that a few detonations of 15 lbs. NEW each. Collection of composite soil samples under baseline, single detonation, and multiple detonation conditions should provide adequate data to evaluate potential impacts to soil and subsequent modifications to the cleanup process, if appropriate.

REFERENCES

Jenkins, T.F., et. al., 1997. *Site Characterization at the Inland Firing Range Impact Area at Fort Ord.* December. Prepared for U.S. Army Corps of Engineers, Sacramento District.

Nichols Research Corporation (NRC), 1996. *Open Burning/Open Detonation, UXO Baseline, Volume 1 - Final Report.* January 31. Sponsored by U.S. Army Engineer Division, Huntsville.

U.S. Department of the Army (Army), 1992. *Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods. Bang Box Test Series, Volume 1, Test Summary*. January. Sponsored by Headquarters, U.S. Army Armament, Munitions, and Chemical Command.

U.S. Army Engineering and Support Center, Huntsville, and Sacramento District Corps of Engineers, 1998. *Engineering Evaluation/Cost Analysis - Phase 2, Former Fort Ord, Monterey, California*. April.

Table 1. Most Prevalent Ordnance Requiring Removal at Former Fort Ord, California

Item Description[1]	**Principal Explosive Component(s)**[2]	**Similar Explosive Component(s) in NRC Study? (Camp Claiborne)**
Dragon Rocket, M223	Octol 70/30 (HMX/TNT)	NO
106mm, M344A1	Comp B (RDX/TNT)	YES
3.5inch Rocket, M28	Comp B (RDX/TNT)	YES
84mm, M136 (AT-4)	Comp B (RDX/TNT)	YES
81mm M43A1	Comp B (RDX/TNT)	YES
66mm TPA, M74	Triethylaluminum	NO
66mm, M72 (LAW Rocket)	Octol 70/30 (HMX/TNT)	NO
2.36 inch Rocket, M6A1	50/50 Pentolite (TNT/ PETN)	YES
60mm, M49A2	Comp B (RDX/TNT)	YES
M9 Rifle Grenade	Comp B (RDX/TNT)	YES
57mm, M306A1	Comp B (RDX/TNT)	YES
40mm, M381	Comp B (RDX/TNT)	YES
40mm, M677 (Mk19)	Cyclotol 70/30 (RDX/TNT)	YES
35mm Subcal, M73	Flash Composition [a]	YES
22mm Subcal for 81mm mortar, M744	Smoke Charge [b]	YES
Small arms (7.62mm, 5.56mm, 50 and 30 cal)	Nitrocellulose, Nitroglycerin	NO
Pyrotechnics (misc. flares and signals)	Illuminant Composition [c]	YES

[1]Source: Engineering Evaluation/Cost Analysis - Phase 2, Former Fort Ord (U.S. Army, 1998)
[2]Source: Army Ammunition Data Sheets

[a] Flash Composition:
- Potassium Perchlorate
- Flaked Aluminum
- Sulfur

[b] Smoke Charge:
- Potassium Perchlorate
- Aluminum Powder

[c] Illuminant Composition (typical):
- Aluminum or Magnesium Powder
- Sodium or Barium Nitrate

Table 2. Target Analytes for Open Detonation Tests at Camp Claiborne and Camp Grant (NRC Study)

Semivolatile Compounds Analyzed Using EPA Method 8270/625

Compound	Compound	Compound
Bis(2-chloroethyl)ether	4-Chlorophenyl phenylether	2-Nitrophenol
1,3-Dichlorobenzene	Fluorene	2,4-Dimethylphenol
1,2-Dichlorobenzene	Azobenzene	2,4-Dichlorophenol
1,4-Dichlorobenzene	Hexachlorobenzene	4-Chloro-3-Methylphenol
Bis(2-chloroisopropyl)ether	Phenanthrene	2,4,6-Trichlorophenol
N-Nitro-n-propylamine	Anthracene	2,4-Dinitrophenol
Hexachloroethane	Dibutyl phthalate	4-Nitrophenol
Nitrobenzene	Fluoranthene	2-Methyl-4,6-Dinitrophenol
Isophorone	Pyrene	Pentachlorophenol
Bis(2-chloroethoxy)methane	Butylbenzyl phthalate	
1,2,4-Trichlorobenzene	3,3′-Dichlorobenzdine	ADDITONAL COMPOUNDS
Naphthalene	Benzo(a)anthracene	1-Methylnaphthalene
Hexachlorobutadiene	Chrysene	Acetophenone
2-Chloronaphthalene	Bis(2-ethylhexyl)phthalate	Diphenylamine
Dimethyl phthalate	Di-n-octyl phthalate	2-Aminonaphthalene
2,6-Dinitrotoluene	Benzo(b)fluoroanthene	1-Nitropyrene
Acenaphthylene	Benzo(k)fluoroanthene	2,5-Diphenyloxazole
Acenaptheme	Benzo(a)pyrene	2-Nitronaphthalene
2,4-Dinitrotoluene	Ideno(1,2,3-cd)pyrene	
Diethyl phthalate	Dibenzo(a,h)anthracene	OTHER COMPOUNDS
Benzidine	Benzo(g,h,l)perylene	2 Methylnaphthalene
4-Bromophenyl phenyl ether	N-Nitrosodiphenylamine	2-&/or 3-Methylphenol
N-Nitrosodimethylamine	Phenol	4-Methylphenol
Hexachlorocyclopentadiene	2-Chlorophenol	2,4,5-Trichlorophenol

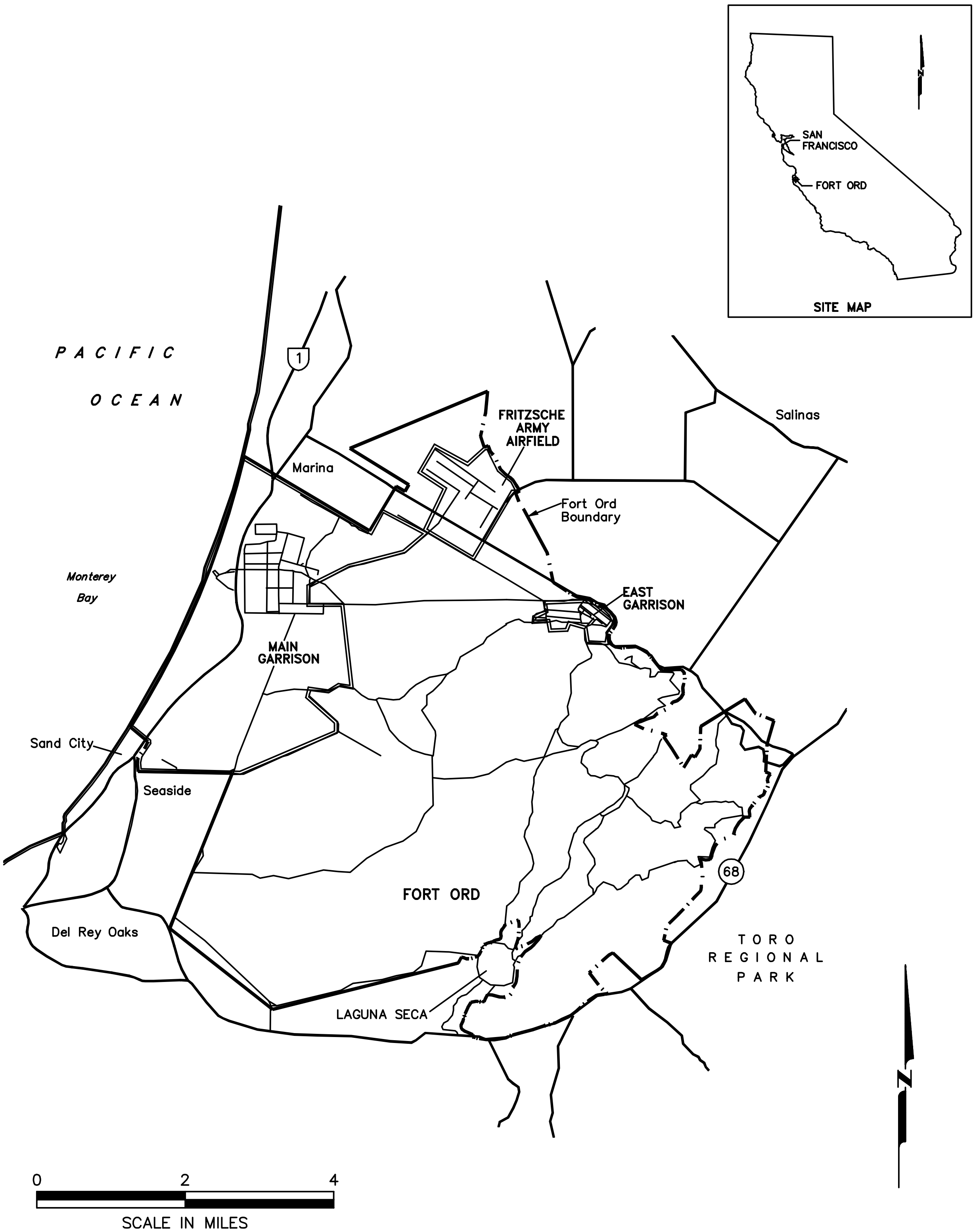
Metals Analyzed Using Method 6010

- Copper
- Lead
- Chromium
- Mercury
- Barium
- Nickel
- Potassium
- Zinc
- Cadmium
- Aluminum
- Calcium
- Titanium

Nitroaromatics and Nitramines Analyzed Using HPLC EPA Method 8330

- HMX
- RDX
- 1,3,5-Trinitrobenzine
- 1,3 Dinitrobenzine
- Nitrobenzene (Surrogate)
- 2,4,6-Trinitrotoluene
- 2-AM-Dinitrotoluene
- 2,4 Dinitotoluene

Source: Nichols Research Corporation (NRC), 1996



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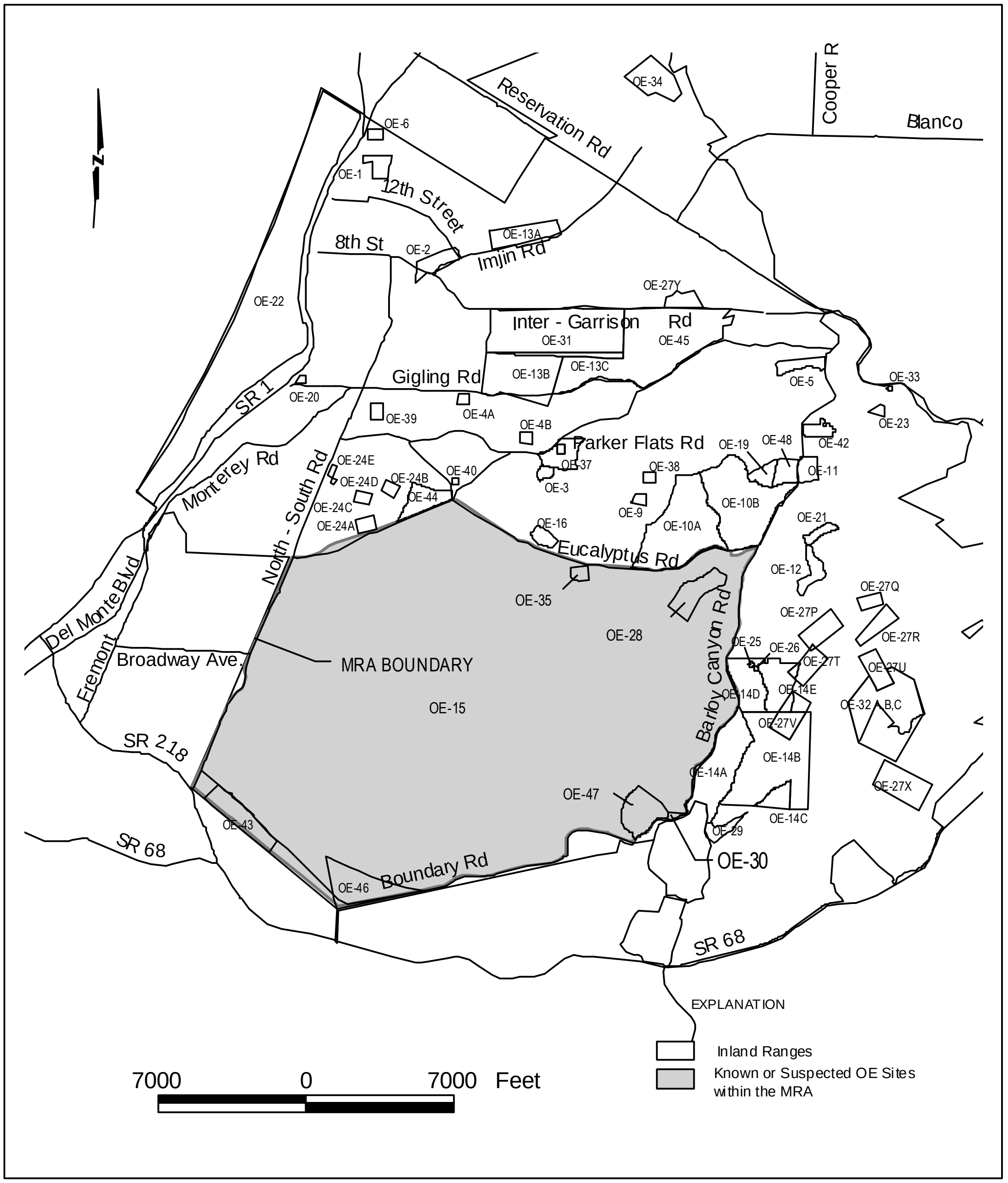
Site Location Map
Sampling and Analysis Plan
Ordnance and Explosives Removal Actions
Former Fort Ord, California

PLATE
1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
TJH	38273 00114		9/98	



OE Areas
Sampling and Analysis Plan
Ordnance and Explosives Removal Actions
Former Fort Ord, California

PLATE
2

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DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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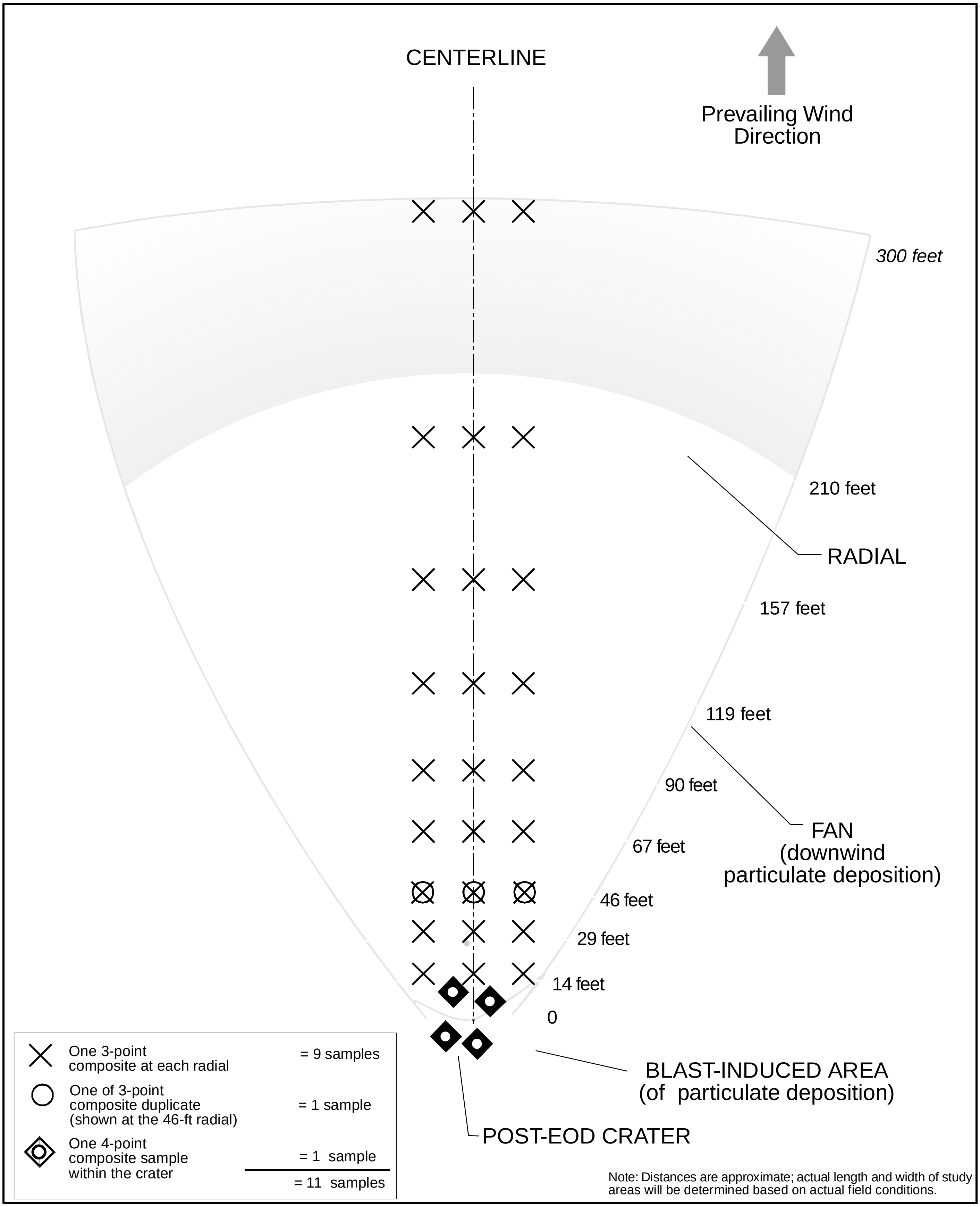

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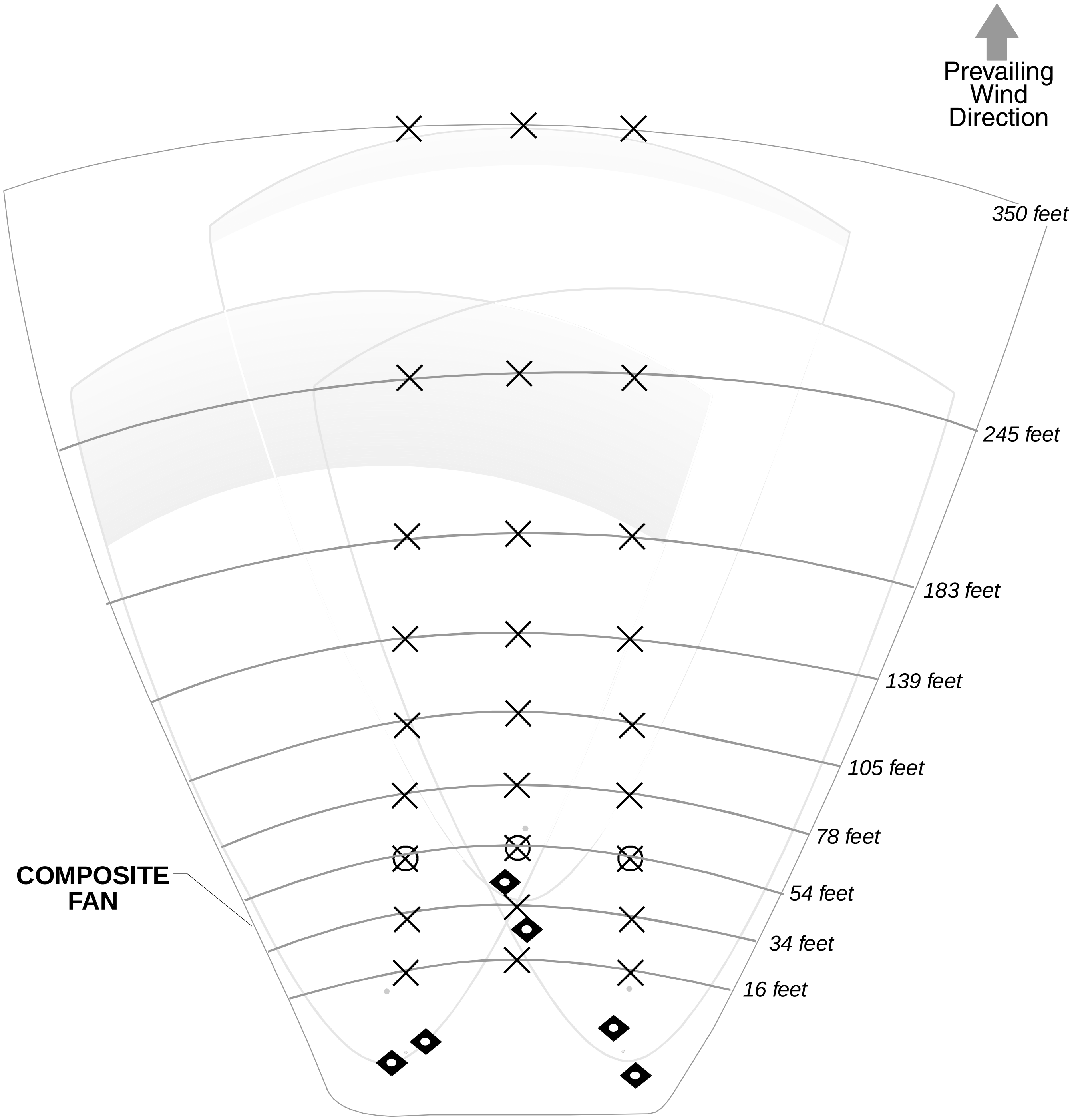
Conceptual Dispersion Model for Single-Detonation EOD Operation
Sampling and Analysis Plan
Ordnance and Explosives Removal Actions
Former Fort Ord, California

PLATE 3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
DJPc	38273 00114		11/98	



X	One 3-point composite at each radial	= 9 samples
○	One 3-point composite duplicate (shown at the 54 ft radial)	= 1 sample
◆	One 6-point composite sample within multiple craters	= 1 sample
		= 11 samples

Note: Distances are approximate; actual length and width of study areas will be determined based on actual field conditions.

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Conceptual Dispersion Model for Multiple-Detonation EOD Operation
Sampling and Analysis Plan
Ordnance and Explosives Removal Actions
Former Fort Ord, California

PLATE 4

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
DJPc	38273 00114		10/98	